

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of

Atty. Docket : US030082

DAVID G. MILLER

Group Art Unit: 3739

Serial No. 10/764,951

Examiner: MATTHEW J. KASZTEJNA

Filed: JANUARY 26, 2004

CONF. NO. 9296

TITLE: APPARATUS AND METHOD FOR DISSIPATING HEAT PRODUCED BY TEE
PROBES

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

APPEAL BRIEF

Sir:

Appellant herewith respectfully presents its Brief on Appeal
as follows:

REAL PARTY IN INTEREST

The real party in interest is Koninklijke Philips Electronics N.V., a corporation of The Netherlands having an office and a place of business at Groenewoudseweg 1, Eindhoven, Netherlands 5621 BA.

RELATED APPEALS AND INTERFERENCES

To the best of Appellant's knowledge and belief, there are no related appeals or interferences.

STATUS OF CLAIMS

Claims 1-14 and 21 are pending in this application. Claims 15-20 are canceled. Claims 1-14 and 21 are rejected in the Final Office Action that issued June 30, 2008. This rejection was upheld, in an Advisory Action that mailed on October 14, 2008 in response to an Amendment After Final Action that was submitted on September 2, 2008. Claims 1-14 and 21 are the subject of this appeal.

STATUS OF AMENDMENTS

An Amendment After Final Action was submitted on September 2, 2008 in response to a Final Office Action mailed on June 30, 2008. The Amendment After Final Action did not include any amendments. In an Advisory Action mailed on October 14, 2008, it is indicated that the after Amendment After Final Action was considered but the Amendment After Final action does not place the application in condition for allowance. This Appeal Brief is in response to the Final Office Action mailed on June 30, 2008, that finally rejected claims 1-14 and 21, which remain finally rejected in the Advisory Action mailed on October 14, 2008.

SUMMARY OF CLAIMED SUBJECT MATTER

The present invention, for example as claimed in claim 1, relates to an endoscopic imaging apparatus including an endoscope including a distal end (see, present patent application FIGs. 2-6, page 4, lines 2-3 and page 7 line 3), at least one ultrasound transducer contained within the distal end (see, present patent application FIGs. 2 and 4, page 4, lines 2-3 and page 7 line 4), and an outer protective shell directly covering the distal end and fabricated from an electrically insulating material having a Thermal Conductance greater than 1 W/M-°K overlaying at least a portion of the distal end (see, present patent application FIGs. 2, 3 and 5, page 4 lines 3-7, page 4, Table 1, and page 7, lines 5-6).

The present invention, for example as claimed in claim 9, relates to an apparatus for dissipating thermal energy produced by an endoscopic imaging apparatus (see, present patent application FIGs. 2-6, page 4, lines 3-8), wherein the apparatus is configured and dimensioned to mate with a distal end of the imaging apparatus for dissipating thermal energy produced at the distal end (see, present patent application FIG. 2, and page 7 lines 22-24), the

apparatus fabricated from an electrically insulating material having a Thermal Conductance greater than 1 W/M-°K and comprising an outer protective shell directly covering the distal end (see, present patent application, page 8 lines 1-2).

The present invention, for example as claimed in claim 21, relates to a device for passively dissipating thermal energy produced by at least one transducer located at a distal end of an endoscopic imaging apparatus (see, present patent application FIGs. 2-6, page 4, lines 3-8), wherein the device includes an outer protective shell directly covering the distal end and is configured and dimensioned to encase the at least one transducer (see, present patent application FIGs. 2, 3 and 5, and page 9 lines 4-5), the device having at least the following properties: electrically insulating; a Thermal Conductance greater than 1 W/M-°K; and substantially non-reactivity in the presence of bodily fluids (see, present patent application FIGs. 2, 3 and 5, and page 4 lines 29-32, page 4, Table 1, and page 9, lines 5-9).

It should be explicitly noted that it is not the Appellant's intention that the currently claimed device and method be limited to operation within the illustrative device and method described

above beyond what is required by the claim language. Further description of the illustrative device and method is provided above indicating portions of the claims which cover the illustrative device and method merely for compliance with requirements of this appeal without intending any further interpreted limitations be read into the claims as presented.

GROUND OF REJECTION TO BE REVIEWED ON APPEAL

Whether claims 1-5, 9, 12-13 and 21 of U.S. Patent Application Serial No. 10/764,951 are anticipated under 35 U.S.C. §102(b) by U.S. Patent No. 5,669,389 to Rotteveel ("Rotteveel").

Whether claims 6-8, 10-11 and 14 of U.S. Patent Application Serial No. 10/764,951 are obvious under 35 U.S.C. §103(a) over Rotteveel in view of U.S. Patent No. 5,738,100 to Yagami ("Yagami").

ARGUMENT

Claims 1-5, 9, 12-13 and 21 are said to be anticipated by Rotteveel.

Appellant respectfully requests the Board to address the patentability of independent claims 1, 9 and 21, and further claims 2-5 and 12-13 as respectively depending from one of independent claims 1 and 9, based on the requirements of independent claims 1, 9 and 21. This position is provided for the specific and stated purpose of simplifying the current issues on appeal. However, Appellant herein specifically reserves the right to argue and address the patentability of claims 2-5 and 12-13 at a later date should the separately patentable subject matter of claims 2-5 and 12-13 later become an issue. Accordingly, this limitation of the subject matter presented for appeal herein, specifically limited to discussions of the patentability of independent claims 1, 9 and 21 is not intended as a waiver of Appellant's right to argue the patentability of the further claims and claim elements at that later time.

The assertions set forth in the Final Office Action and the Advisory Action are respectfully traversed. It is respectfully submitted that claims 1-14 and 21, generally, and claims 1-5, 9, 12-13 and 21, particularly addressed in this portion of the Brief, are allowable over Rotteveel for at least the following reasons.

Rotteveel shows an endoscope probe with a probe head having a cavity or circular aperture in which is placed an ultrasonic transducer (see, Rotteveel, Abstract). The probe head of Rotteveel's endoscope is constructed of a holder and a free end that is shut-off by a semicircular wall (see, Rotteveel, Col. 2 lines 58-64). The holder has a circular aperture for placement of the ultrasonic transducer (see, Rotteveel, Col. 2 lines 64-65 and FIG. 2).

The cavity or aperture in the probe head is sealed with an acoustically transparent lens and the transducer is coupled acoustically to a fixed cap (see, Rotteveel, Abstract). Rotteveel states:

A hard concave acoustic lens 81 which rotates along with the transducer is fitted on the transducer and can be, for example, glued on the transducer. The concave lens can be an acrylic lens or an anamorphic type of lens made of hard epoxy resin. The lengthwise direction of the cavity corresponds to that of the individual elements of

the transducer. The cavity of the lens in the example shown is filled with a so-called flat filler 82 which together with the lens forms a plane-parallel unit ... An ultrasonic sound-transmitting cap 85 is fitted, also in a scaling manner, in the ring 83. The cap 85 is preferably made of hard material such as methylpentene copolymer silicone rubber, and in the example shown is glued to the ring 83, as indicated schematically at 86. The ring 83, which can be made of, e.g. glass ceramic material, lies with the bottom axial plane against the lens 81. Between the cap and the lens is a chamber 87 which along the periphery is bounded by the ring 83 and which is filled with an electrically non-conducting degassed fluid. [see, Rotteveel, Col. 5 lines 31-57, emphases added].

In contrast to Rotteveel's endoscope, claims 1, 9, and 21 are directed to an apparatus having an endoscope including a distal end; at least one ultrasound transducer contained within the distal end; and an outer protective shell directly covering the distal end and fabricated from an electrically insulating material having a Thermal Conductance greater than 1 W/M-°K overlaying at least a portion of said distal end.

Endoscopic probes used currently in medical examinations are susceptible to overheating, and are often limited by the thermal rise of the probe surface from transducer self-heating during normal operation (e.g., see, present patent application, page 1 lines 24-25). A cause of the overheating phenomenon is due to the

inefficient conduction of heat from the transducer to the patient (e.g., see, present patent application, page 2 lines 13-15).

Nowhere does Rotteveel show an outer protective shell covering the distal end of an endoscope in which the outer protective shell is fabricated from an electrically insulating material having a Thermal Conductance greater than 1 W/M-°K as substantially recited in each of claims 1, 9 and 21.

Rotteveel states in contrast that the cavity or aperture containing the ultrasonic transducer is sealed by the lens, the flat filler, the sound-transmitting cap, and a chamber filled with an electrically non-conducting degassed fluid (see, Rotteveel, Col. 3 lines 21-24 and col. 5 lines 31-57). It is respectfully submitted that none of Rotteveel's materials have a Thermal Conductance greater than 1 W/M-°K.

Rotteveel fails to provide an example of any electrically non-conducting degassed fluid nor any example of a flat filler. Therefore, nowhere does Rotteveel show that the electrically non-conducting degassed fluid or the flat filler has a Thermal Conductance of greater than 1 W/M-°K.

Rotteveel's lens is made from an acrylic or a hard epoxy resin (see, Rotteveel, Col. 5, lines 31-35), and the sound-transmitting cap is made from methylpentene copolymer silicone rubber (see, Rotteveel, Col. 5 lines 48-51).

One of ordinary skill in the art of physics or material science would have understood at the time the application was filed that none of acrylic, epoxy, and silicone rubber has a Thermal Conductance of greater than 1 W/M-°K, to which claims 1, 9 and 21 are directed.

While the Final Office Action has maintained the prior rejection of the claims, particularly that the elements 81, 82, 87 and 85 of Rotteveel disclose an overall thermal conductivity of greater than 1 W/M-°K, the Response to Arguments section of the Final Office Action contained on page 4, modifies this rejection in stating that (emphasis added) "Rotteveel teaches that the use of a flat filler is not strictly necessary and that a suitable screening foil, for example aluminum capton can also be placed between the flat filler and the concave acoustic lens. It is [alleged in the Final Office Action that it is] well known in the art that aluminum capton has a thermal conductance greater than 1 W/M-°K." No

support for the allegation of the thermal conductance of aluminum capton is provided although the Amendment After Final Action submitted on September 2, 2008 refuted this position. The Appellant respectfully traverses this assertion of the properties of aluminum capton.

Kapton™ is a material produced by Dupont. A review of a datasheet from Dupont regarding the thermal conductivity of Kapton reveals that Kapton has a thermal conductivity of 0.12 W/M-°K (data sheet attached in Appendix B following this Brief). Goodfellow.com reveals that an aluminum filled polyimide has a thermal conductivity of 0.45 W/M-°K (data sheet attached in Appendix B following this Brief). None of these references supports the allegation that "[i]t is well known in the art that aluminum capton has a thermal conductance greater than 1 W/M-°K" as provided in the Final Office Action.

The Manual of Patent Examining Procedure (MPEP) §2131 provides that a claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described in a single prior art reference. The identical invention must be shown in as complete detail as contained in the claim.

Appellant submits that the Final Office Action has failed to make a prima facie case of anticipation because the simple recitation of aluminium capton as a screening foil does not satisfy MPEP §2131 as anticipatory with regard to the recitation of "an outer protective shell directly covering said distal end and fabricated from an electrically insulating material having a Thermal Conductance greater than 1 W/M-°K overlaying at least a portion of said distal end" as recited in claim 1 and as substantially recited in each of claims 9 and 21.

If the assertion in the Office Action is in effect that it is inherent that aluminum capton has a thermal conductance greater than 1 W/M-°K, this assertion is respectfully refuted. Appellant respectfully notes that a missing element is inherently present in a reference only if that element necessarily follows from what has been expressly described, and would be so recognized by one of skill in the art. Mere possibilities or even probabilities are not enough; necessity recognized by those of skill in the art is

required.¹

The M.P.E.P. echoes this case law.

The fact that a certain result or characteristic may occur or be present in the prior art is not sufficient to establish the inherency of that result or characteristic.

M.P.E.P. § 2112 (emphasis in original) (citations omitted).

Further, the following is also emphasized:

In relying upon the theory or inherency, the examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic necessarily flows from the teaching of the applied prior art.

M.P.E.P. § 2112 (emphasis in original) (citations omitted).

It is well established that a recited element or step is inherently present in a prior art reference only if that element is necessarily present or necessarily performed in that reference, and

¹ The Federal Circuit has clearly set out the standard for inherency in, e.g., Continental Can Co. v. Monsanto Co., 20 U.S.P.Q.2d 1746, 1749 (Fed. Cir. 1991) (emphasis added):
To serve as an anticipation when the reference is silent about the asserted inherent characteristic, such gap in the reference may be filled with recourse to extrinsic evidence. Such evidence must make clear that the missing descriptive matter is necessarily present in the thing described in the reference and that it would be so recognized by persons of ordinary skill. In re Oelrich, 212 U.S.P.Q. 323, 326 (C.C.P.A. 1981) (quoting Hansgirc v. Kemmer, 40 U.S.P.Q. 665, 667 (C.C.P.A. 1939)) provides: "Inherency,

further that its presence or performance would be recognized by one of ordinary skill in the art from what has been expressly described. Second, the Office Action must provide objective evidence or cogent technical reasoning to support a contention of inherency.

The Advisory Action has maintained this position without providing any documentary evidence supporting this allegation although as stated above, this position was traversed in the Amendment After Final Action previously submitted. The Advisory Action attempts to redress this deficiency by referring to the conductance of aluminum is 250 W/m-K. The Table referenced in the Advisory Action is attached hereto in Appendix B as previously provided to facilitate this review. Rotteveel, Col. 5, lines 40-41 is cited in the Advisory Action in support of the allegation that Rotteveel teaches aluminum. This position is restfully traversed.

Rotteveel specifically states in the section cited in the Advisory Action that "[a] suitable screening foil, for example of aluminum captonTM (polyimide) can be placed between the flat filler

however may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient."
This citation is also set out in M.P.E.P. § 2131.01(d).

and the concave acoustic lens." Rotteveel does not disclose or suggest aluminum foil, but merely recites aluminum capton, which as shown above does not have a Thermal Conductance greater than 1 W/M-°K.

Further, MPEP § 2144.03 A. Reliance on Common Knowledge in the Art or "Well Known" Prior Art [R-6] - 2100 Patentability, states that (emphasis added):

Official notice without documentary evidence to support an examiner's conclusion is permissible only in some circumstances. While "official notice" may be relied on, these circumstances should be rare when an application is under final rejection or action under 37 CFR 1.113. Official notice unsupported by documentary evidence should only be taken by the examiner where the facts asserted to be well-known, or to be common knowledge in the art are capable of instant and unquestionable demonstration as being well-known. As noted by the court in *In re Ahlert*, 424 F.2d 1088, 1091, 165 USPQ 418, 420 (CCPA 1970), the notice of facts beyond the record which may be taken by the examiner must be "capable of such instant and unquestionable demonstration as to defy dispute" (citing *In re Knapp Monarch Co.*, 296 F.2d 230, 132 USPQ 6 (CCPA 1961))

The MPEP makes clear that (emphasis in original and additionally added) "[i]t would not be appropriate for the examiner to take official notice of facts without citing a prior art reference where the facts asserted to be well known are not capable

of instant and unquestionable demonstration as being well-known. For example, assertions of technical facts in the areas of esoteric technology or specific knowledge of the prior art must always be supported by citation to some reference work recognized as standard in the pertinent art. *In re Ahlert*, 424 F.2d at 1091, 165 USPQ at 420-21. See also *In re Grose*, 592 F.2d 1161, 1167-68, 201 USPQ 57, 63 (CCPA 1979) ('[W]hen the PTO seeks to rely upon a chemical theory, in establishing a prima facie case of obviousness, it must provide evidentiary support for the existence and meaning of that theory.'); *In re Eynde*, 480 F.2d 1364, 1370, 178 USPQ 470, 474 (CCPA 1973) ('[W]e reject the notion that judicial or administrative notice may be taken of the state of the art. The facts constituting the state of the art are normally subject to the possibility of rational disagreement among reasonable men and are not amenable to the taking of such notice.')."

The MPEP is clear that (emphasis added) "[i]t is never appropriate to rely solely on 'common knowledge' in the art without evidentiary support in the record, as the principal evidence upon which a rejection was based. *Zurko*, 258 F.3d at 1385, 59 USPQ2d at 1697 ('[T]he Board cannot simply reach conclusions based on its own

understanding or experience-or on its assessment of what would be basic knowledge or common sense. Rather, the Board must point to some concrete evidence in the record in support of these findings.'). While the court explained that, 'as an administrative tribunal the Board clearly has expertise in the subject matter over which it exercises jurisdiction,' it made clear that such 'expertise may provide sufficient support for conclusions [only] as to peripheral issues.' *Id.* at 1385-86, 59 USPQ2d at 1697. As the court held in *Zurko*, an assessment of basic knowledge and common sense that is not based on any evidence in the record lacks substantial evidence support. *Id.* at 1385, 59 USPQ2d at 1697. ***

The Appellant has refuted these positions stated in the Final Office Action and reiterated in the Advisory Action, yet the Examiner has failed to provide any documentary evidence that it is inherent that aluminum capton inherently has a Thermal Conductance greater than 1 W/M-°K. Further, the Appellant has provided clear evidence refuting this position.

Accordingly, it is respectfully submitted that the Final Office Action has failed to make a prima facie case that Rotteveel anticipates each of claims 1, 9 and 21.

The Advisory Action attempts to address further remarks to inconsistencies in the conductance shown for aluminum oxide in the tables provided, however, it is respectfully submitted that these remarks are not relevant as to whether the aluminum capton of Rotteveel inherently has a Thermal Conductance greater than 1 W/M-°K which should be clear from all of the above, it des not.

Yagami is also discussed in the Advisory Action, however, it is respectfully submitted that Yagami is not part of the 35 U.S.C. §102(b) rejection of claims 1-5, 9, 12-13 and 21 and therefore is not relevant to this discussion.

Based on the foregoing, it is respectfully submitted that the endoscopic imaging apparatus of claim 1 is not anticipated or made obvious by the teachings of Rotteveel. For example, Rotteveel does not disclose or suggest, an endoscopic imaging apparatus that amongst other patentable elements, comprises (illustrative emphasis added) "an endoscope including a distal end; at least one ultrasound transducer contained within said distal end; and an outer protective shell directly covering said distal end and fabricated from an electrically insulating material having a Thermal Conductance greater than 1 W/M-°K overlaying at least a

portion of said distal end" as recited in claim 1, and as similarly recited in each of claims 9 and 21.

Clearly, Rotteveel does not address this limitation and it obviously is not an inherent characteristic of the system of Rotteveel. Further, although this characteristic of the pending claims has been pointed out and maintained over six responses to Office Actions as well as a prior Appeal Brief, the Examiner has failed to provide a shred of documentary evidence supporting the allegation that Rotteveel teaches this recitation of the claims.

Based on the foregoing, the Appellants respectfully submit that independent claims 1, 9 and 21 are patentable over Rotteveel and notice to this effect is earnestly solicited.

Claims 2-5 and 12-13 respectively depend from one of claims 1 and 9 and accordingly are allowable for at least this reason as well as for the separately patentable elements contained in each of said claims. Accordingly, separate consideration of each of the dependent claims is respectfully requested.

Claims 6-8, 10-11 and 14 are said to be unpatentable over Rotteveel in view of Yagami.

Yagami is cited for allegedly showing elements of the dependent claims yet does not cure the deficiencies in Rotteveel.

However, it must be pointed out that while Yagami is cited for showing alumina covering a transducer positioned at a distal end of an endoscope and a thermal conductance greater than 1 W/M-°K, approximately 30 W/M-°K (see, Final Office Action, page 4), it is respectfully submitted that reliance on Yagami for this feature is misplaced. Yagami does not disclose a transducer positioned at a distal end of an endoscope (see, Yagami, FIG. 1, cited in the Final Office Action and transducer 11).

Further, while the Appellant has identified a need for a material, such as a given ceramic having a high thermal conductivity as described on page 4 of the present application (as cited in the Final Office Action), it is improper for the Final Office Action to utilize the teachings of the present patent application as support for the current rejection of the claims.

In any event, Yagami does not cure the deficiencies in Rotteveel and accordingly, it is respectfully submitted that claims

6-8, 10-11 and 14 are allowable at least based on respective dependence from one of independent claims 1 and 9.

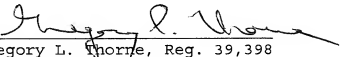
In addition, Appellants deny any statement, position or averment of the Examiner that is not specifically addressed by the foregoing argument and response. Any rejections and/or points of argument not addressed would appear to be moot in view of the presented remarks. However, the Appellants reserve the right to submit further arguments in support of the above stated position, should that become necessary. No arguments are waived and none of the Examiner's statements are conceded.

CONCLUSION

Claims 1-14 and 21 are patentable over any of Rotteveel alone and in combination with Yagami.

Thus the Examiner's rejection of claims 1-14 and 21 should be reversed.

Respectfully submitted,

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APPENDIX A

CLAIMS ON APPEAL

1. (previously presented) An endoscopic imaging apparatus comprising: an endoscope including a distal end; at least one ultrasound transducer contained within said distal end; and an outer protective shell directly covering said distal end and fabricated from an electrically insulating material having a Thermal Conductance greater than 1 W/M-°K overlaying at least a portion of said distal end.
2. (original) The endoscopic imaging apparatus as in claim 1, further comprising: controls for controlling the movement of the distal end; a signal processor for processing received signals from said at least one ultrasound transducer; and means for energizing the at least one ultrasonic transducer.
3. (original) The apparatus as in claim 1, wherein said covering is in thermal contact with the at least one ultrasound transducer.

4. (original) The apparatus as in claim 1, wherein said material is non-toxic.

5. (original) The apparatus as in claim 1, wherein said material is non-reactive in the presence of bodily fluids.

6. (original) The apparatus as in claim 1, wherein said material is selected from the group consisting of ceramic and diamond-coated copper.

7. (previously presented) The apparatus as in claim 1, wherein said material comprises an Alumina-based ceramic.

8. (original) The apparatus as in claim 1, wherein said material has a Thermal Conductance of approximately 30 W/M-° K.

9. (previously presented) An apparatus for dissipating thermal energy produced by an endoscopic imaging apparatus, wherein the apparatus is configured and dimensioned to mate with a distal end of said imaging apparatus for dissipating thermal energy produced

at said distal end, said apparatus fabricated from an electrically insulating material having a Thermal Conductance greater than 1 W/M-°K and comprising an outer protective shell directly covering said distal end.

10. (original) The apparatus as in claim 9, wherein said material is selected from the group consisting of ceramic and diamond-coated copper.

11. (previously presented) The apparatus as in claim 9, wherein said material comprises an Alumina-based ceramic.

12. (original) The apparatus as in claim 9, wherein said material is non-toxic when in contact with a patient's internal structures.

13. (original) The apparatus as in claim 9, wherein said material is non-reactive in the presence of bodily fluids.

14. (original) The apparatus as in claim 9, wherein said material has a Thermal Conductance of approximately 30 W/M-°K.

15-20. (cancelled)

21. (previously presented) A device for passively dissipating thermal energy produced by at least one transducer located at a distal end of an endoscopic imaging apparatus, wherein said device comprises an outer protective shell directly covering said distal end and is configured and dimensioned to encase the at least one transducer, said device having at least the following properties: electrically insulating; a Thermal Conductance greater than 1 W/M-°K; and substantially non-reactivity in the presence of bodily fluids.

APPENDIX B

Evidence on Appeal

1. Datasheet from Dupont showing the thermal conductivity of Kapton.
2. Listing from Goodfellow.com showing thermal conductivity of aluminum filled polyimide.
3. Table showing thermal conductivity of alumina.

-- See following attached --

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Kapton® is used in applications such as the solar array and for thermal management in the United States space program.



General Information

Kapton® polyimide film possesses a unique combination of properties that make it ideal for a variety of applications in many different industries. The ability of Kapton® to maintain its excellent physical, electrical, and mechanical properties over a wide temperature range has opened new design and application areas to plastic films.

Kapton® is synthesized by polymerizing an aromatic dianhydride and an aromatic diamine. It has excellent chemical resistance; there are no known organic solvents for the film.

Kapton® does not melt or burn as it has the highest UL-94 flammability rating: V-0. The outstanding properties of Kapton® permit it to be used at both high and low temperature extremes where other organic polymeric materials would not be functional.

Adhesives are available for bonding Kapton® to itself and to metals, various paper types, and other films.

Kapton® polyimide film can be used in a variety of electrical and electronic insulation applications: wire and cable tapes, formed coil insulation, substrates for flexible printed circuits, motor slot liners, magnet wire insulation, transformer and capacitor insulation, magnetic and pressure-sensitive tapes, and tubing. Many of these applications are based on the excellent balance of electrical, thermal, mechanical, physical, and chemical properties of Kapton® over a wide range of temperatures. It is this combination of useful properties at temperature extremes that makes Kapton® a unique industrial material.

Three types of Kapton® are described in this bulletin:

- Kapton® Type HN, all-polyimide film, has been used successfully in applications at temperatures as low as -269°C (-452°F) and as high as 400°C (752°F).

Type HN film can be laminated, metallized, punched, formed, or adhesive coated. It is available as 7.5 µm (0.3 mil), 12.5 µm (0.5 mil), 19 µm (0.75 mil), 25 µm (1 mil), 50 µm (2 mil), 75 µm (3 mil), and 125 µm (5 mil) films.

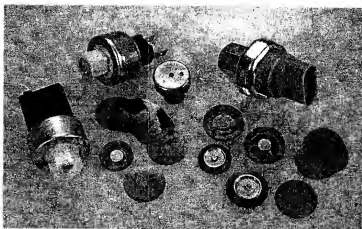
- Kapton® Type VN, all-polyimide film with all of the properties of Type HN, plus superior dimensional stability. Type VN is available as 12.5 µm (0.5 mil), 19 µm (0.75 mil), 25 µm (1 mil), 50 µm (2 mil), 75 µm (3 mil), and 125 µm (5 mil) films.
- Kapton® Type FN, a Type HN film coated on one or both sides with Teflon® FEP fluoropolymer resin, imparts heat sealability, provides a moisture barrier, and enhances chemical resistance. Type FN is available in a number of combinations of polyimide and Teflon® FEP thicknesses (see Table 16).

Note: In addition to these three types of Kapton®, films are available with the following attributes:

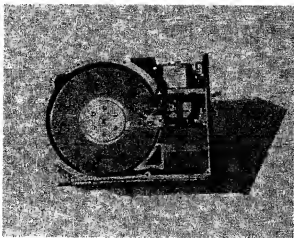
- antistat
- thermally conductive
- polyimides for fine line circuitry
- cryogenic insulation
- corona resistant
- pigmented for color
- conformable
- other films tailored to meet customers' needs

Data for these films are covered in separate product bulletins, which can be obtained from your DuPont representative.

The Chemical Abstracts Service Registry Number for Kapton® polyimide film is [25036-53-7].



Kapton® withstands the harsh chemical and physical demands on diaphragms used in automotive switches.



Kapton® is used in numerous electronic applications, including hard disk drives.

Physical and Thermal Properties

Kapton® polyimide films retain their physical properties over a wide temperature range. They have been used in field applications where the environmental temperatures were as low as -269°C (-452°F) and as high as 400°C (752°F).

Complete data are not available at these extreme conditions, and the majority of technical data presented in this section falls in the 23 to 200°C (73 to 392°F) range.

Table 1
Physical Properties of Kapton® Type 100 HN Film, 25 µm (1 mil)

Physical Property	Typical Value at		Test Method
	23°C (73°F)	200°C (392°F)	
Ultimate Tensile Strength, MPa (psi)	231 (33,500)	139 (20,000)	ASTM D-882-91, Method A*
Yield Point at 3%, MPa (psi)	69 (10,000)	41 (6000)	ASTM D-882-91
Stress to Produce 5% Elongation, MPa (psi)	90 (13,000)	61 (9000)	ASTM D-882-91
Ultimate Elongation, %	72	83	ASTM D-882-91
Tensile Modulus, GPa (psi)	2.5 (370,000)	2.0 (290,000)	ASTM D-882-91
Impact Strength, N cm (ft-lb)	78 (0.58)		DuPont Pneumatic Impact Test
Folding Endurance (MIT), cycles	285,000		ASTM D-2176-89
Tear Strength—Propagating (Elmendorf), N (lbf)	0.07 (0.02)		ASTM D-1922-89
Tear Strength—Initial (Graves), N (lbf)	7.2 (1.6)		ASTM D-1004-90
Density, g/cc or g/mL	1.42		ASTM D-1505-90
Coefficient of Friction—Kinetic (Film-to-Film)	0.48		ASTM D-1894-90
Coefficient of Friction—Static (Film-to-Film)	0.63		ASTM D-1894-90
Refractive Index (Sodium D Line)	1.70		ASTM D-542-90
Poisson's Ratio	0.34		Avg. Three Samples Elongated at 5%, 7%, 10%
Low Temperature Flex Life	Pass		IPC TM 650, Method 2.6.18

*Specimen Size: 25 x 150 mm (1 x 6 in); Jaw Separation: 100 mm (4 in); Jaw Speed: 50 mm/min (2 in/min); Ultimate refers to the tensile strength and elongation measured at break.

Table 2
Thermal Properties of Kapton® Type 100 HN Film, 25 µm (1 mil)

Thermal Property	Typical Value	Test Condition	Test Method
Melting Point	None	None	ASTM E-794-85 (1989)
Thermal Coefficient of Linear Expansion	20 ppm/°C (11 ppm/°F)	-14 to 38°C (7 to 100°F)	ASTM D-696-91
Coefficient of Thermal Conductivity, W/m K	0.12	296 K	ASTM F-433-77 (1987)*1
$\frac{\text{cal}}{\text{cm-sec-}^\circ\text{C}}$	2.87×10^{-4}	23°C	
Specific Heat, J/g K (cal/g-°C)	1.09 (0.261)		Differential Calorimetry
Flammability	94V-0		UL-94 (2-8-85)
Shrinkage, %	0.17 1.25	30 min at 150°C 120 min at 400°C	IPC TM 650, Method 2.2.4A ASTM D-5214-91
Heat Sealability	Not Heat Sealable		
Limiting Oxygen Index, %	37		ASTM D-2863-87
Solder Float	Pass		IPC TM 650, Method 2.4.13A
Smoke Generation	DM = <1	NBS Smoke Chamber	NFPA-258
Glass Transition Temperature (T _g)	A second order transition occurs in Kapton® between 360°C (680°F) and 410°C (770°F) and is assumed to be the glass transition temperature. Different measurement techniques produce different results within the above temperature range.		



Polyimide

PI

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Common Brand Names:

Kapton, Kinel, Upilex, Upimol, Vespel

General Description:

General Description : Normally infusible, coloured (often amber) high performance polymers with predominantly aromatic molecules of high thermal stability. Semi-fabricated shapes are usually supplied by the polymer manufacturer and made by powder sintering or working with more tractable pre-cursors and completing polymerisation in final form, though some melt-processable grades of resin are manufactured. They have excellent high temperature properties and radiation resistance, inherently low flammability and smoke emission, low creep and high wear resistance and are very expensive. They have moderately high water absorption and are prone to hydrolysis and attack by alkalis and concentrated acids.

A widely used form is Kapton® film, made in thicknesses from 0.008 to 0.125mm and which is a transparent amber colour. Thicker polyimide items are usually opaque. A range of Kapton film variants are also available. In each of these, a large measure of Kapton's basic properties are combined with an extra attribute eg increased electrical or thermal conductivity, improved corona resistance, opacity and thermoplasticity.

Films are used for capacitors, insulation, printed circuit boards and in aerospace; other applications include engine components, bearings and mechanical parts exposed to radiation.

Explanation of Kapton grade descriptions

HN Regular Kapton - Transparent Amber

CB Opaque black version of HN

MT Aluminium oxide filled, increased thermal conductivity, opaque yellow

MTB Opaque black version of MT

CR Improved corona resistance - translucent yellow

XC Electrically (semi-)conductive - opaque black

KJ Thermoplastic - transparent yellow

Chemical Resistance

Acids - concentrated

Poor

Acids - dilute	Fair
Alcohols	Poor
Alkalis	Poor
Aromatic hydrocarbons	Good
Greases and Oils	Good
Halogenated Hydrocarbons	Good
Halogens	Fair
Ketones	Good

Electrical Properties

Dielectric constant @1MHz	3.4
Dielectric strength (kV mm ⁻¹)	22
Dissipation factor @ 1kHz	0.0018
Surface resistivity (Ohm/sq)	10 ¹⁶
Volume resistivity (Ohmcm)	10 ¹⁸

Mechanical Properties

Coefficient of friction	0.42
Elongation at break (%)	8-70
Hardness - Rockwell	E52-99
Izod impact strength (J m ⁻¹)	80
Tensile modulus (GPa)	2.0-3.0
Tensile strength (MPa)	70-150

Physical Properties

Density (g cm ⁻³)	1.42
Flammability	V0
Limiting oxygen index (%)	53
Radiation resistance	Good
Refractive Index	1.66
Resistance to Ultra-violet	Poor
Water absorption - over 24 hours (%)	0.2-2.9

Thermal Properties

Coefficient of thermal expansion (x10 ⁻⁶ K ⁻¹)	30-60
Heat-deflection temperature - 1.8MPa (C)	360
Lower working temperature (C)	-270
Specific heat (J K ⁻¹ kg ⁻¹)	1090
Thermal conductivity (W m ⁻¹ K ⁻¹)	0.10-0.35 @ 23C
Upper working temperature (C)	250-320

Properties Polyimide Film

Property	Value				
Material	HN	CB	MT	MTB	CR
Coefficient of thermal expansion x10 ⁻⁶ K ⁻¹	20				
Corona Resistance @ 20kV mm ⁻¹ 50 hr	200				>100,
Density g cm ⁻³	1.42	1.42	1.85	1.85	1.54
Dielectric Constant @ 1MHz	3.4				
Dielectric Constant @ 1kHz	3.4	4.5	4.2	4.2	3.9
Dielectric Strength @25µm thick	300	80	165	70 @ 0.075mm	290
Dissipation Factor @1MHz	0.01				
Dissipation Factor @1kHz	0.0018	0.19			
Elongation at Break %	70	45	50-60	50-60	0.003 45

Initial Tear Strength	$\text{g } \mu\text{m}^{-1}$	20				
Moisture absorption	%	2.8		3		3
Permeability to Carbon Dioxide @25C	$\text{x}10^{-13} \text{ cm}^3 \cdot \text{cm cm}^{-2} \text{ s}^{-1} \text{ Pa}^{-1}$	0.5				
Permeability to Hydrogen @25C	$\text{x}10^{-13} \text{ cm}^3 \cdot \text{cm cm}^{-2} \text{ s}^{-1} \text{ Pa}^{-1}$	1				
Permeability to Nitrogen @25C	$\text{x}10^{-13} \text{ cm}^3 \cdot \text{cm cm}^{-2} \text{ s}^{-1} \text{ Pa}^{-1}$	0.03				
Permeability to Oxygen @25C	$\text{x}10^{-13} \text{ cm}^3 \cdot \text{cm cm}^{-2} \text{ s}^{-1} \text{ Pa}^{-1}$	0.1				
Permeability to Water @25C	$\text{x}10^{-13} \text{ cm}^3 \cdot \text{cm cm}^{-2} \text{ s}^{-1} \text{ Pa}^{-1}$	400				
Permeability to Water @38C	$\text{x}10^{-13} \text{ cm}^3 \cdot \text{cm cm}^{-2} \text{ s}^{-1} \text{ Pa}^{-1}$	500				
Shrinkage @400C	%	1.2-1.5	1	1	1	0.6
Surface Resistivity	Ohm/sq					3.6x10
Tensile modulus	GPa	2.5	2.7	4	4	3.2
Tensile strength	MPa	230	135	125	125	150
Thermal Conductivity @23C	$\text{W m}^{-1} \text{ K}^{-1}$	0.16		0.45	0.45	0.38
Volume Resistivity	Ohmcm	1.5x10 ¹⁷	10 ¹³	10 ¹⁴	10 ¹⁴	2.3x10

Properties Polyimide Chopped Fibre

Property		Value
Specific Tenacity	cN/tex	38
Extension to break	%	30
Limiting Oxygen Index	%	38
Shrinkage @180C	%	<1
Tenacity	GPa	540

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Thermal Conductivity of some common Materials

Thermal conductivity of some common materials as aluminum, asphalt, brass, copper, steel and many more

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Thermal conductivity is the quantity of heat transmitted through a unit thickness in a direction normal to a surface of unit area, due to a unit temperature gradient under steady state conditions.

Thermal conductivity, or heat transfer coefficients, of some common materials and products can be found in the table below:

Material/Substance	Thermal Conductivity - k - (W/m K)		
	Temperature ($^{\circ}\text{C}$)		
	25	125	225
Acetone	0.16		
Acrylic	0.2		
Air	0.024		
Alcohol	0.17		
Aluminum	250	255	250
Aluminum Oxide	30		
Ammonia	0.022		
Antimony	18.5		
Argon	0.016		
Asbestos-cement board	0.744		
Asbestos-cement sheets	0.166		
Asbestos-cement	2.07		
Asbestos, loosely packed	0.15		
Asbestos mill board	0.14		
Asphalt	0.75		
Balsa	0.048		
Bitumen	0.17		
Benzene	0.16		
Beryllium	218		
Brass	109		
Brick dense	1.31		
Brick work	0.69		
Cadmium	92		
Carbon	1.7		
Cement, portland	0.28		
Cement, mortar	1.73		
Chalk	0.09		
Cobalt	69		

Thermal Conductivity of some common Materials

Appendix A

Concrete, light	0.42		
Concrete, stone	1.7		
Constantan	22		
Copper	401	400	398
Corian (ceramic filled)	1.06		
Corkboard	0.043		
Cork, regranulated	0.044		
Cork, ground	0.043		
Cotton	0.03		
Carbon Steel	54	51	47
Cotton Wool insulation	0.029		
Diatomaceous earth (Sil-c-cel)	0.06		
Earth, dry	1.5		
Ether	0.14		
Epoxy	0.35		
Felt insulation	0.04		
Fiberglass	0.04		
Fiber insulating board	0.048		
Fiber hardboard	0.2		
Fireclay brick 500°C	1.4		
Foam Glass	0.042		
Gasoline	0.15		
Glass	1.05		
Glass, Pearls, dry	0.18		
Glass, Pearls, saturated	0.76		
Glass, window	0.96		
Glass, wool Insulation	0.04		
Glycerol	0.28		
Gold	310	312	310
Granite	1.7 - 4.0		
Gypsum or plaster board	0.17		
Hairfelt	0.05		
Hardboard high density	0.15		
Hardwoods (oak, maple..)	0.16		
Helium	0.142		
Hydrogen	0.168		
Ice (0°C, 32°F)	2.18		
Insulation materials	0.035 - 0.16		
Iridium	147		
Iron	80	68	60
Iron, wrought	58		
Iron, cast	55		
Kapok insulation	0.034		
Kerosene	0.15		
Lead Pb	35		
Leather, dry	0.14		
Limestone	1.26 - 1.33		
Magnesia insulation (85%)	0.07		
Magnesium	156		
Marble	2.6		



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Thermal Conductivity & Coefficient of Expansion

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Substance	Thermal Conductivity (W/cm·°C)	Coefficient of Thermal Expansion (ppm/°C)	Density (g/cm ³)	Specific Thermal Conductivity ^b (W/cm·°C)
Air (still)	0.0003			
Alumina	0.276			
Alumina (85%)	0.118			
Aluminum	2.165	0.23	2.7	0.81
Beryllia (99.5%)	1.969			
Beryllia (97%)	1.575			
Beryllia (95%)	1.161			
Beryllium	1.772			
Beryllium-Copper	1.969			
Boron Nitride	0.394			
Brass (70/30)	1.220			
Copper	3.937	0.17	8.9	0.45
Copper/Invar ^c /Copper	1.64	0.084	9.4	.020
Copper/Mo ^d /Copper	1.82	0.060	9.9	0.18
Copper/Mo ^d -Cu/Copper	2.45-2.80	0.60-0.10	9.4	0.26-0.30
Diamond (room temp)	6.299			
Epoxy	0.002			
Epoxy (thermally conductive)	0.008			
FR-4 (G-10)	0.003			
GaAs	0.591			
Glass	0.008			
Gold	2.913			
Heatsink Compound	0.004			
Helium (liquid)	0.000307			
Invar	0.11	0.013	8.1	0.014
Iron	0.999			
Kovar	0.17	0.59	8.3	0.020
Lead	0.343			
Magnesium	1.575			
Mica	0.007			
Molybdenum	1.299			
Monel	0.197			

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
Mylar	0.002			
Nickel	0.906			
Nitrogen (liquid)	0.001411			
Phenolic	0.002			
Platinum	0.734			
Sapphire (a-axis)	0.32			
Sapphire (c-axis)	0.35			
Silicon (pure)	1.457			
Silicon (0.0025 Ω -cm)	1.457			
Silicon Carbide	0.90			
Silicon Dioxide (amorphous)	0.014			
Silicon Dioxide (quartz, a-axis)	0.059			
Silicon Dioxide (quartz, c-axis)	0.11			
Silicone Grease	0.002			
Silicone Rubber	0.002			
Silicon Nitride	0.16 - 0.33			
Silver	4.173			
Stainless Steel (321)	0.146			
Stainless Steel (410)	0.240			
Steel (low carbon)	0.669			
Teflon	0.002			
Tin	0.630			
Titanium	0.219	0.086	4.4	0.016
Tungsten	1.969			
Water	0.0055			
Zinc	1.024			

a: Approximate values from 0 °C to 100 °C

b: Thermal conductivity divided by specific gravity (introduced by Dr. Carl Zweben & K.A. Schmidt)


c: Invar

d: Molybdenum


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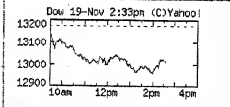
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APPENDIX C

Related Proceedings of Appeal

None